

Effects of Heat Stress, Carbon Dioxide, and Light Regime on the Breakdown of Gametophytic Self-Incompatibility

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Self-incompatibility in *Petunia hybrida*

Mature flower (self-incompatible) →

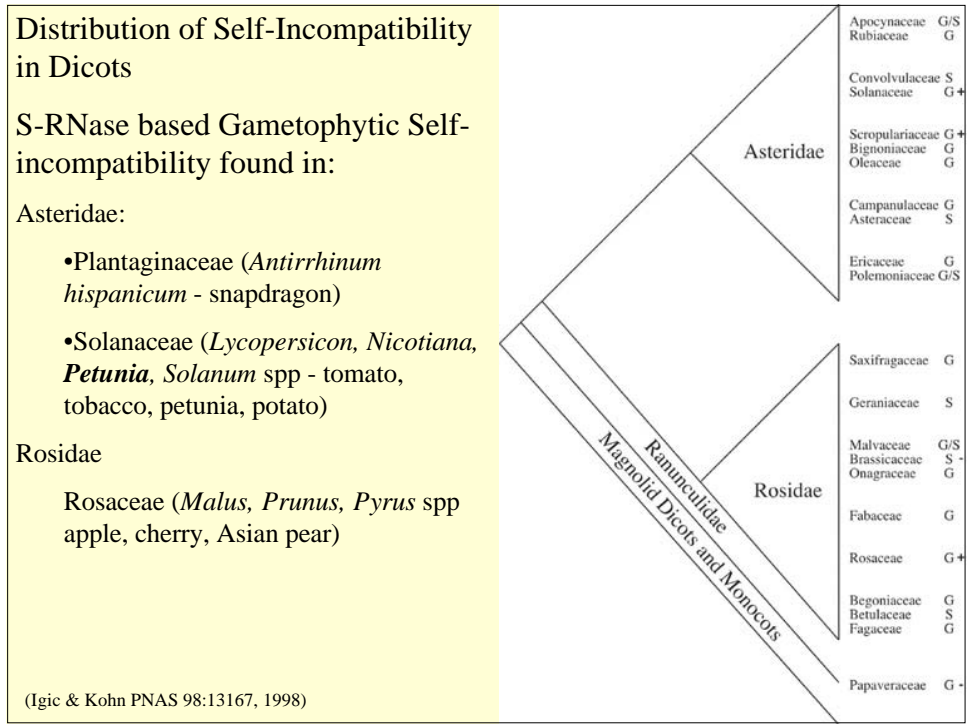
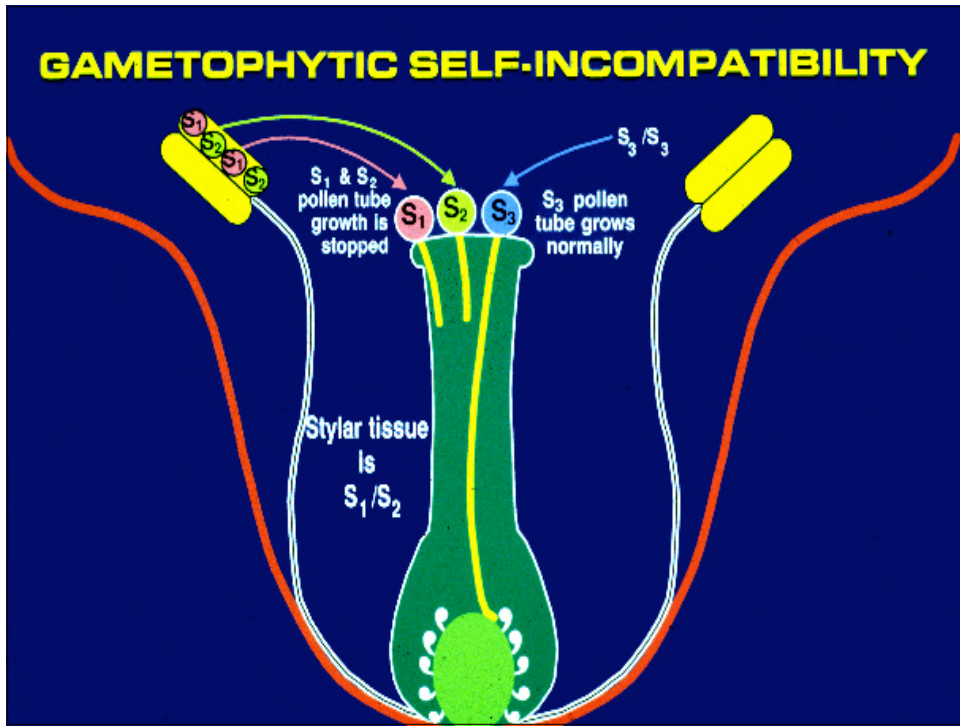
“-3 day” flower (self-compatible) →

“-1 day” flower (self-incompatible) →

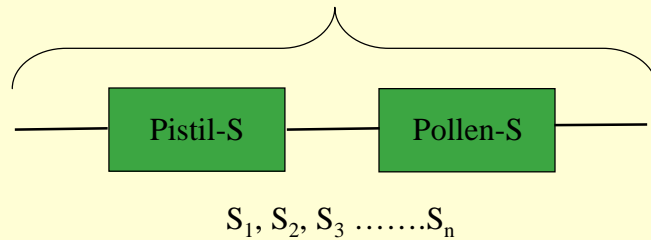


- Mature flowers actively reject “self” pollen (barrier to inbreeding)

- How does the plant recognize “self” versus “non-self”?



The S-locus



Highly polymorphic, suppressed for recombination, ancient

Size varies: *Petunia*, >5 MB, 328 kb contig, S-RNase, SLF 161 kb apart

Antirrhinum, ~ 64 kb

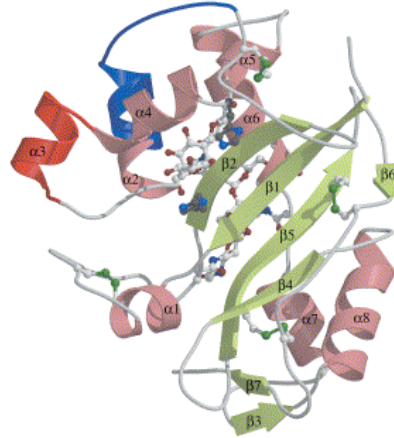
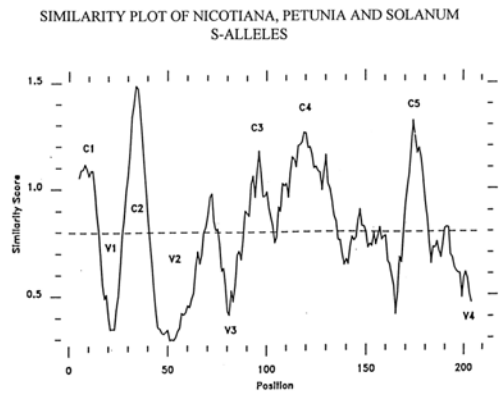
Prunus, ~ 70 kb

Defined by extent of polymorphism in genome

Proteins with known or presumed roles in GSI

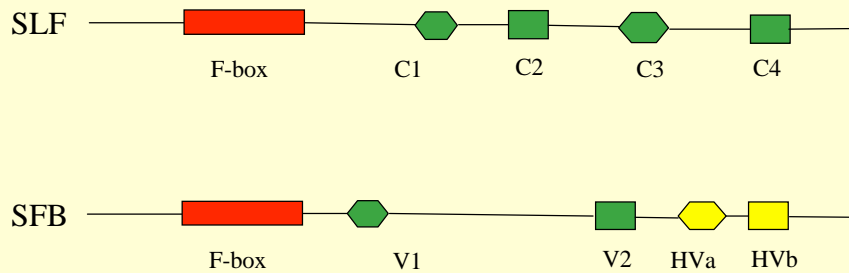
- Recognition proteins (S-locus)
 - S-RNase (style recognition factor)
 - SLF/SFB (pollen recognition factor)
- Non-S-locus, required proteins
 - HT-B, 120 kDa
- Interacting proteins (pollen+)
 - SBP1, SSK1, Cullin, E2
- Interacting proteins (style)
 - TTS, NaPPPB

S-Ribonuclease Structure



Ida et al., JMB 314: 103, 2001)

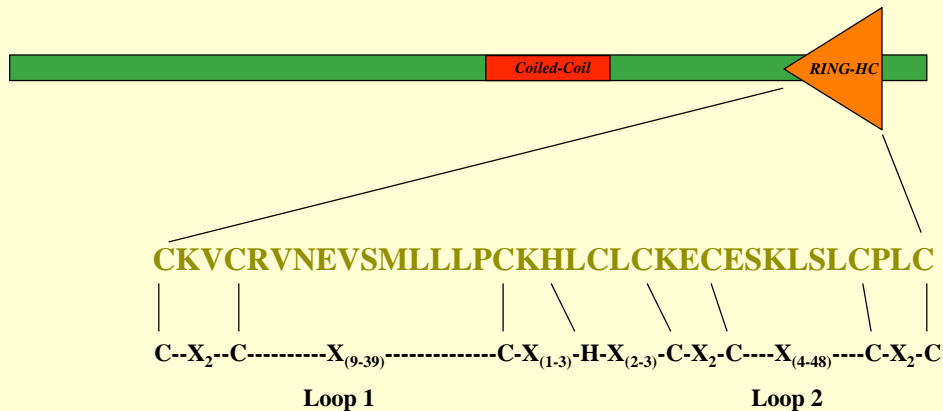
SLF Structure



375 aa

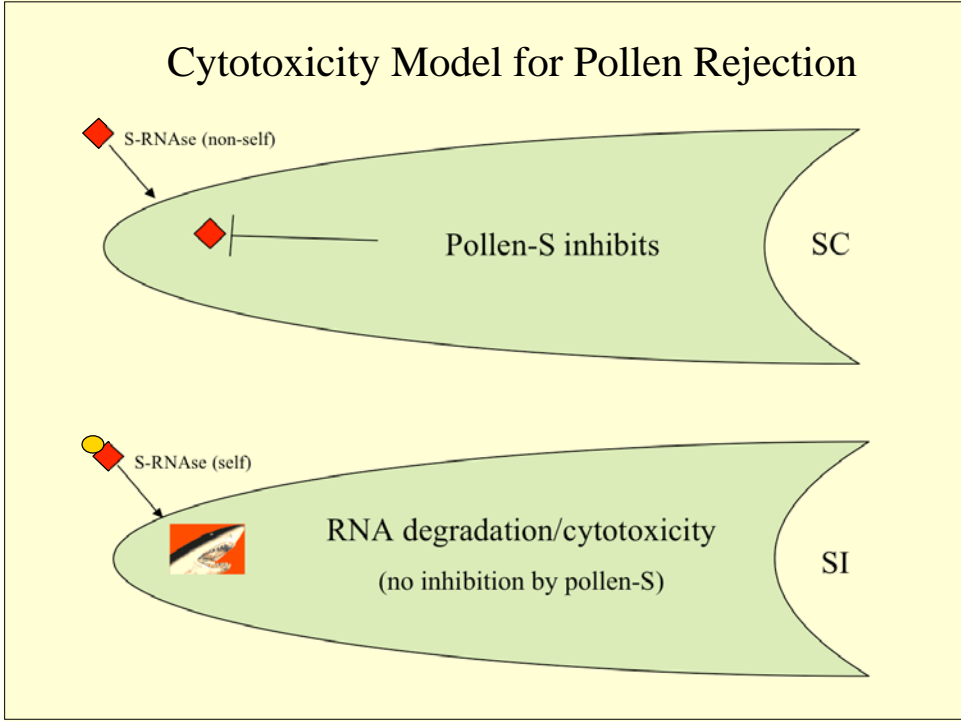
adapted from Zhang & Xue, 2008

PhSBP1 Protein Domain Structure



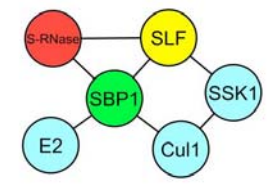
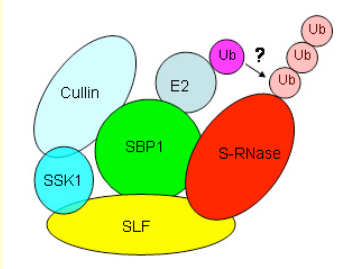
Cytotoxicity Model of Pollen Rejection

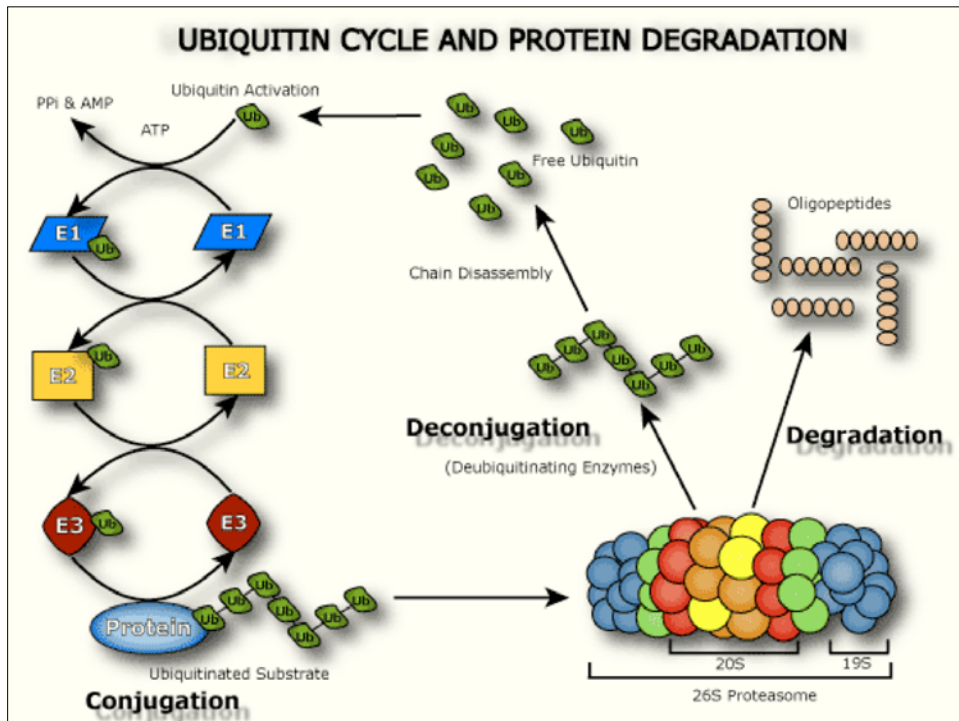
- S-RNase is style component
- S-RNase has signal peptide; secreted into intercellular spaces of transmitting tract; accumulates to high concentration
- S-RNase is taken up into pollen tubes (no allelic specificity of uptake)
- Ribonuclease activity is required for pollen rejection (RNase⁻ mutants can't reject pollen)
- Correlation of pollen RNA degradation and SI (cause? or effect?)



Pollen-S Function (Model #1)

- SLF and SBP1 are E3 ubiquitin ligase proteins
- Protein interactions demonstrated with SCF-like complex components
- Preferential targeting (ubiquitination & degradation) of non-self S-RNases in compatible pollination
- Data?

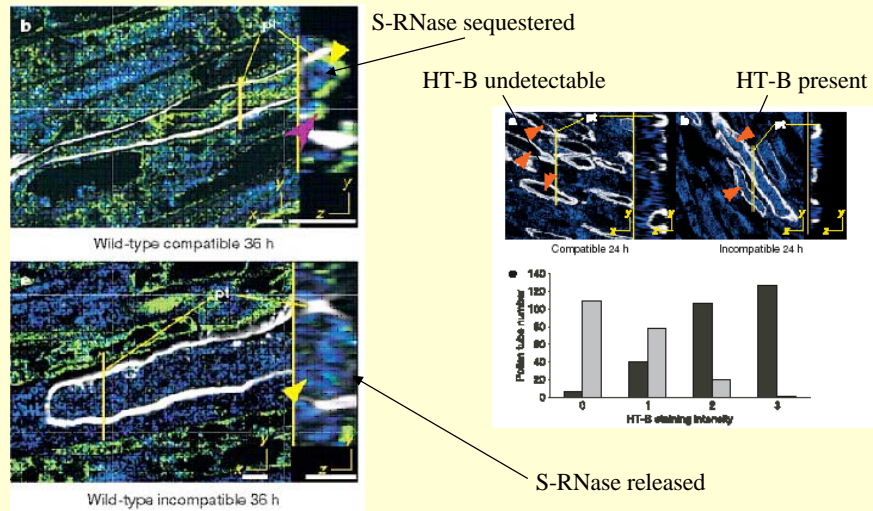





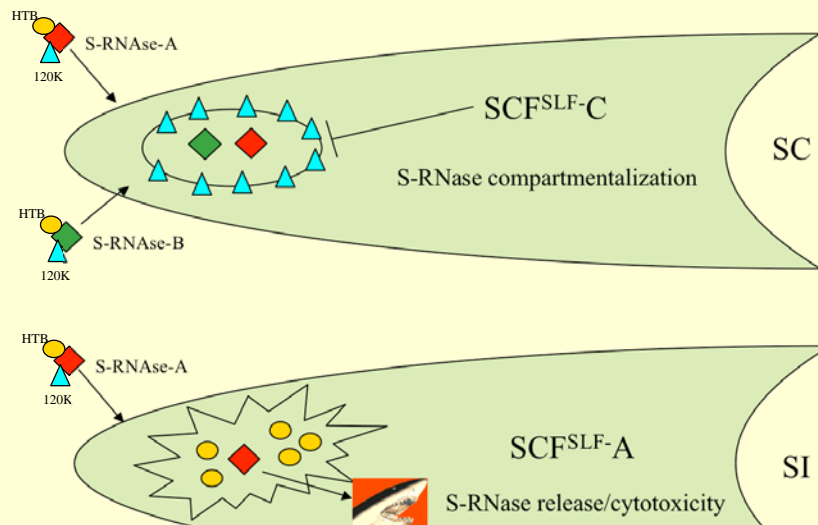
Pollen-S Function (#2)

- S-RNase is initially sequestered in vacuolar like compartment in both SI and SC pollinations
- In SC pollinations, S-RNase remains sequestered, HT-B is undetectable (degraded?)
- In SI pollinations, S-RNase is released, HT-B is prevalent (stabilized?)

Sequestration in Vacuolar Compartment



Target & Recognition?



What does any of this have to do with



Plant Stress??

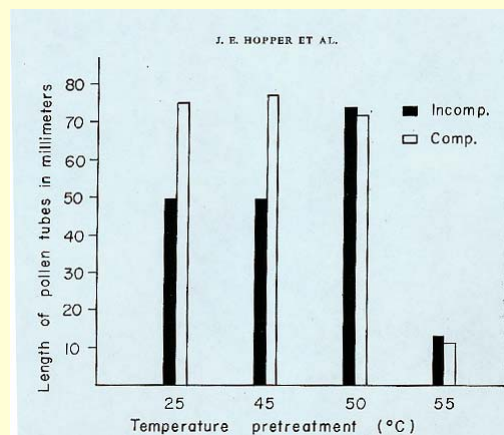
Breakdown of GSI

- Polyploidy
- Style-part and pollen-part mutants
- Quantitative (polygenic?) PSC
- Environmental Breakdown
 - Heat
 - Winter light
 - Nutrition

Inactivation of Self-Incompatibility following temperature pretreatments of styles in *Lilium longiflorum*

Hopper *et al.*, Euphytica 16: 215-220 (1967)

Heat inactivation in lily



- Pretreatment of detached styles at 50 C inactivated SI response
- Heat-treatment of whole plant resulted in 40% fruit set vs 0% fruit set without heat treatment
- Effect was specific to the style (heat-treated pollen unaffected)

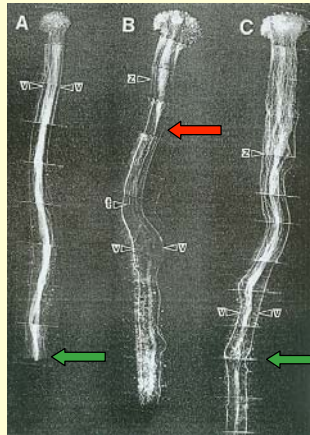
Effects of temperature, light, nutrients and
Carbon dioxide on the strength of the self-
incompatibility response in detached flowers
of *Lycopersicon peruvianum*

Webb & Williams, Annals of Botany 61:
395-404 (1988)

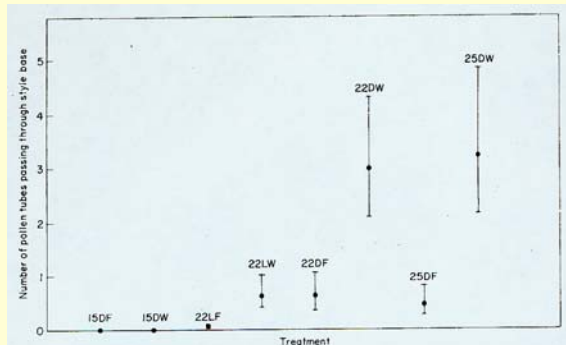
Heat/Nutritional effects in wild tomato

- Pollinated styles of detached flowers
- Various treatments
- Monitored extent of pollen tube growth by fluorescence microscopy using aniline blue (stains callose, β -1,3-glucan)
- Increased temperature = increased length of SI pollen tubes
- Effect only seen when carbon source (sucrose) was absent (i.e. in H₂O or mannitol)

Heat and nutritional effects in wild tomato



SC SI SI + heat



D=dark, L=light, F=full nutrient, W=water

15, 22, 25 = temperatures

- Incompatible pollen tubes grew longer at elevated temperatures, but only in dark on water (sucrose or light reversed effect)

- No fertilization occurred, tubes did not enter ovule

Winter Environment

- Winter environment increases self seed yield in self-incompatible (SI) *Petunia hybrida* clones. Flaschenreim and Ascher, *Euphytica* 29: 581-584 (1980)
- Progeny testing for self-incompatibility in inbred lines of *Petunia hybrida*. Flaschenreim and Ascher, *Hortscience* 15: 26-27 (1980)

Winter environment increases self seed yield in self-incompatible (SI) *Petunia hybrida* clones. Flaschenreim and Ascher, Euphytica 29: 581-584 (1980)

F1 Plant	Parents	Parental	F1	Mean Self Seed		
		Genotypes*	Genotype	December	July	October
416	579-1 x 137-3	S1S1 x S1S1	S1S1	0.0	0.0	0.0
418	579-1 x 582-5	S1S1 x S1S1	S1S1	0.8	0.0	0.0
415	567-10 x 604-1	? x S2S2	?S2	80.1	0.0	0.0
417	579-1 x 192-3	S1S1 x S3S3	S1S3	174.6	3.3	64.7
419	579-1 x 604-1	S1S1 x S2S2	S1S2	177.6	ND	93.0
423	604-1 x 192-6	S2S2 x S3S3	S2S3	215.6	28.6	115.2

Progeny testing for self-incompatibility in inbred lines of *Petunia hybrida*. Flaschenreim and Ascher, Hortscience 15: 26-27 (1980)

PARENTS				PROGENY			
Plant ID	Genotype	Generation	Generation	PSC		% zero seed	
				Summer	Winter	Summer	Winter
75-567-10		I-1	I-2	0-46	0-72	50	16
75-604-1	S2S2	I-4	I-5	0	0	100	100
75-192-3		I-4	I-5	0	0-53	100	40
75-652-4	S1S1	I-6	I-7	0-15	8-46	14	0
75-582-5	S1S1	I-6	I-7	0	0-4	100	75
75-579-1	S1S1	I-7	I-8	0-5	0	83	100
75-630-1	S3S3	I-7	I-8	0-17	0-100	80	10

Stress Effects on GSI

- Increased temperature, winter light conditions lead to full or partial breakdown of SI response
- Effect appears to be on style components, not pollen
- In some cases, effect reversed by providing carbon source (sucrose or photosynthesis)
- Dependent on genetic background of specific plant
- Probably NOT an effect on S-RNase?

